BY ORDER OF THE SECRETARY OF THE AIR FORCE

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Safety

DESIGN, EVALUATION, TROUBLESHOOTING, AND MAINTENANCE CRITERIA FOR NUCLEAR WEAPON SYSTEMS

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This Instruction implements AFPD 91-1, *Nuclear Weapons and Systems Surety*. This publication is consistent with AFPD 13-5, *Air Force Nuclear Enterprise.* It specifies the criteria for maintaining and troubleshooting loaded nuclear weapon systems. It directs Air Force activities to comply with the minimum Air Force safety criteria to develop and evaluate nuclear weapon systems for nuclear safety design certification. It applies to individuals at all levels, including Air Force Reserve Command (AFRC) and Air National Guard (ANG), that design, develop, modify, evaluate, support, or operate a nuclear weapon system. Ensure all records created as a result of processes prescribed in this publication are maintained in accordance with AFMAN 33-363, *Management of Records*, and disposed of per the Air Force Records Disposition Schedule (RDS) located in the Air Force Records Information Management System (AFRIMS). Requests for waivers must be submitted through the chain of command to the appropriate Tier waiver approval authority. Refer recommended changes and questions about this publication to the Office of Primary Responsibility (OPR) using the AF Form 847, R*ecommendation for Change of Publication*; route AF Form 847s from the field through the appropriate functional chain of command. Send major command (MAJCOM) supplements to this instruction to AFSEC/SEW, 9700 G Avenue, Kirtland AFB NM 87117-5670 for coordination before publication.

SUMMARY OF CHANGES

This interim change revises AFI 91-107 by incorporating AFI33-360 guidance to include tier waiver requirements.

Section A—Scope and Responsibilities

1. Application of Safety Criteria. Air Force activities shall apply Department of Defense and Air Force safety criteria to design, develop, evaluate, troubleshoot, certify, and maintain nuclear weapon systems. Weapons systems designers should constantly seek to design systems that significantly exceed minimum safety standards.

1.1. Department of Defense (DoD) Safety Standards. The DoD Nuclear Weapon System Safety Standards form the basis for the Air Force nuclear weapon system safety design certification program IAW DODD 3150.2M, *Nuclear Weapons System Safety Program Manual*.

1.2. Nuclear Safety Design Certification. AFMAN 91-118, *Safety Design and Evaluation Criteria for Nuclear Weapon Systems*, and AFMAN 91-119, *Safety Design and Evaluation Criteria for Nuclear Weapons Systems Software*, contain the minimum design and evaluation criteria required to safety design certify nuclear weapon systems according to AFI 91-103, *Air Force Nuclear Safety Design Certification Program*.

1.2.1. The criteria in AFMAN 91-118 and AFMAN 91-119 does not invalidate the safety requirements in other DoD publications. Air Force activities must apply whichever criteria are most stringent.

1.2.2. The weapon system designer may add reasonable safety features to improve safety yet meet operational design requirements because the Air Force goal is to design a system that significantly exceeds the basic safety criteria.

1.2.3. The Air Force or the Department of Defense may prohibit or restrict operational use of a nuclear weapon system if the minimum safety criteria are not satisfied.

1.3. Definition of Requirements. Design agencies implement safety criteria from the start of weapon system development by including them in appropriate formal source documents. These documents include the Program Management Directive, Initial Capabilities Document, Capability Development Document, Operational Plan Data Document, Stockpile-to-Target Sequence, Military Characteristics, and Weapon System Specifications.

1.4. Modifications to Existing Systems. This instruction does not require modifications of an existing operational system solely to meet enhanced safety criteria implemented after the system became operational. However, when modifying an existing system apply these criteria to at least the part of the system being modified.

1.5. Troubleshooting and Maintenance. Weapon system designers must apply safety criteria established by the DoD and Air Force when developing technical orders (TO) or other certified procedures for troubleshooting and maintaining loaded nuclear weapon systems (that is, a combat delivery-capable system with one or more nuclear weapons mechanically and electrically connected in a normal operational configuration). Field-level maintenance personnel must use these criteria to perform troubleshooting and maintenance operations.

2. Responsibilities.

2.1. Air Force Safety Center, Weapons Safety Division (AFSEC/SEW).

2.1.1. Develops Air Force safety design and evaluation criteria.

2.1.2. Approves waiver and deviation requests.

2.1.3. Identifies criteria for, and approves troubleshooting and maintenance procedures and operations on loaded nuclear weapon systems.

2.2. Major Commands (MAJCOM).

2.2.1. Ensure troubleshooting and maintenance procedures and operations on loaded nuclear weapon systems comply with the criteria outlined in this AFI.

2.2.2. Ensure new weapon system developments and modifications to existing weapon systems comply with the minimum Air Force safety design and evaluation criteria specified in AFMAN 91-118 and AFMAN 91-119.

2.2.3. Request any necessary deviations and provide supporting engineering analyses per Section B.

Section B—Deviations

3. Deviations to Air Force Safety Design and Evaluation Criteria:

3.1. Requests for Deviations. Some innovative designs or advances in technology, while conflicting with the specific criteria in AFMAN 91-118 and AFMAN 91-119, may appear to meet the objectives of the DoD Nuclear Weapon System Safety Standards or may provide significant safety advancements. In these cases, the engineering MAJCOM must send a deviation request to AFSEC/SEW. Send the request and supporting documents early enough in the system development to allow for an adequate analysis and to minimize the impact on system development if AFSEC/SEW does not approve the deviation.

3.2. Supporting Documents. A deviation request must include an engineering analysis that shows how the proposed design meets or exceeds the intent of the design criteria.

Section C—General Design Philosophy and Numerical Requirements

4. Nuclear Weapon System Safety Design Philosophy. The Air Force is responsible for protecting against the premature detonation of a nuclear weapon in both normal and credible abnormal environments. Nuclear weapon system designs provide such protection by controlling the system's critical functions in the sequence that leads to weapon detonation. To a significant extent, nuclear safety depends on the primary safety devices and the features that control the critical functions of Authorization, Prearming, Launching, Releasing, Arming, and Targeting.

5. Critical Function Numerical Requirements. To demonstrate adequate control of critical functions, nuclear weapon system designs must meet Air Force-established numerical probability requirements.

5.1. For normal environments, the weapon system designer must show within the calculated probability of occurrence that inadvertent prearming, launching, releasing or jettisoning, arming, or erroneous targeting are highly unlikely during the system's lifetime.

5.2. For credible abnormal environments, the weapon system designer must incorporate safety features that serve as positive measures into the design of combat delivery vehicles to protect against inadvertent critical function activation.

5.3. Consult Tables 1 and 2 for the Air Force-established numerical probability requirements. Table 1 gives the probability requirements for obtaining an unintentional significant nuclear yield (greater than 4 pounds TNT equivalent) from nuclear bombs, warheads, and other nuclear devices because of faults and failures in the nuclear weapon system. Table 2 gives the probability requirements for preventing inadvertent critical function activation because of system faults and failures.

Table 1. Unintentional Significant Nuclear Yield Numerical Requirements for NuclearBombs, Warheads, and Other Nuclear Devices.

RULE	A	B
	The probability of obtaining a nuclear yield is less than	**in the absence of**
1	1×10^{-9} per weapon over the stockpile lifetime	bomb or warhead-unique prearming, environment or trajectory stimuli.
2	1×10^{-4} per event (see note)	the arming signal.
3	1×10^{-6} per weapon during exposure to abnormal environments	unique prearming or environmental stimuli.
NOTE: The Air Force defines an "event" as the application of a prearm command and deliberate deployment (weapon launch or release).		

Table 2. Inadvertent Critical Function Activation Numerical Requirements.

RULE	A	B	C
	For the critical function of…	**The probability of faults and failures in the nuclear weapon system will result in…**	**will be less than…**
1	Authorization	Not applicable	(See note 1)
2	Prearming	inadvertent transmission of the prearm command signals	1×10^{-6} per combat delivery vehicle over the system's lifetime in normal environments. (See note 2)

3	Arming	an Arming and Fuzing (A&F) system failure in a normal environment after the A&F system has been prearmed but before launch or release	1×10^{-4} per prearmed weapon
4	Launching	accidental propulsion system ignition	1×10^{-7} per missile over the system's lifetime in normal environments.
		an inadvertent programmed launch of a ground-launched missile during a fully assembled weapon system operation	1×10^{-12} per missile over the system's lifetime in normal environments
5	Releasing	an inadvertent release or jettison of a bomb or missile when the release system is locked	1×10^{-6} per weapon station over the system's lifetime in normal environments. (See note 4)
		an inadvertent release or jettison of a bomb or missile when the release system is unlocked	1×10^{-3} per unlocking event normal environments. (See note 4)
6	Targeting	the erroneous issuance of the good guidance signal	1×10^{-3} per missile
7	(See note 5)	an inadvertent application of power signals (other than the prearm command) to the warhead/bomb interface	1×10^{-4} per combat delivery vehicle over the system's lifetime in normal environments

NOTES:

1. Safety evaluations of combat delivery aircraft systems must consider the authorization is part of the command and control function and assume the authorization device has been activated. Safety criteria must be met with the authorization device activated. For ground-launched missile systems (for which the user accepts the restriction that the authorization device will not be activated until immediately before intended use of the missile), safety studies and calculations may recognize and take credit for any safety enhancements the authorization device provides.

2. Designers must include positive safety features to prevent inadvertent prearming in credible abnormal environments.

3. "Accidental ignition" does not include non-propulsive burning or explosion in the propulsion system.

4. "Inadvertent release or jettison" doesn't include cases when weapons separate from the aircraft because of catastrophic structural failure of the aircraft rather than operation of the

5. Although not a critical function, weapon system designers must apply this numerical requirement as an additional positive safety measure.

Section D—Troubleshooting and Maintenance Operations

6. General Criteria. When a fault occurs on a loaded nuclear weapon system, the primary consideration is to ensure the system is safe and weapons are not subjected to inadvertent power application or control signals.

6.1. Weapon system designers must define allowable troubleshooting and maintenance operations for loaded nuclear weapon systems in applicable weapon system TOs or other certified procedures. Troubleshooting and maintenance operations must:

6.1.1. Prohibit using any nuclear weapon as a troubleshooting tool. **(T-0)**.

6.1.2. Only use nuclear certified equipment listed in the Master Nuclear Certification Listing (MNCL) and published technical procedures. Common use items as identified in AFI 91-103 may be used. **(T-1)**.

6.1.3. Be consistent with applicable nuclear weapon system safety rules and approved technical data. **(T-0)**.

6.1.4. Require nuclear weapons be immediately and safely isolated from potential danger while maintaining appropriate physical security when a malfunction occurs. **(T-1)**.

6.2. If the authorized procedures do not adequately address the specific fault, the MAJCOM using the procedures must consult with the engineering MAJCOM Safety Office, the Air Force Nuclear Weapons Center, Nuclear Capabilities Directorate (AFNWC/NC), and AFSEC/SEW.

6.3. Field-level maintenance personnel must not perform maintenance operations that affect the nuclear weapon system's structural, propulsion, or electrical and hydraulic power systems unless the Air Force has established specific procedures for these operations. The purpose of this restriction is to protect against the possibility of exposing nuclear weapons to an adverse environment, particularly if a safety-related incident occurs. **(T-0)**.

6.4. The operating MAJCOM Safety must request approval from AFSEC/SEW to conduct other maintenance operations prohibited by these criteria but having a valid operational requirement.

7. Criteria Unique to Aircraft Systems

7.1. **Nuclear System Faults.** When a nuclear system fault occurs on a loaded nuclear combat aircraft, cease current operation and take appropriate actions to identify, locate, and correct the fault if permitted in accordance with technical guidance. The engineering MAJCOM determines whether the system fault is critical by conducting a technical assessment of its potential impact on the nuclear weapons or the weapon system's primary

nuclear safety features and the possible hazards associated with troubleshooting the fault. The MAJCOM's determination is the basis for any T.O. procedure that permits troubleshooting. Troubleshooting procedures must use built-in test (BIT) system capabilities, rather than determinations by field-level personnel, to identify faults and use only initial fault detection data to identify the fault, and prohibit diagnostic testing to identify the fault while nuclear weapons are electrically mated. **(T-1)**.

7.1.1. **Critical Faults.** For critical faults, isolate the affected nuclear weapons from the fault before initiating troubleshooting. The manner in which weapons are isolated depends on the type of fault and the potential for inadvertent application of power or control signals to the weapon interface. Ways to isolate weapons include downloading the weapons; demating the electrical signal lines to the weapons and mechanically safing the release system; and demating the electrical signal lines to both the weapons and the release system. **(T-0)**.

7.1.1.1. If authorized procedures are insufficient or inappropriate or if uncertainty exists about nuclear weapon impacts or the proper maintenance response, the operating MAJCOM must consult with the AFNWC/NC to determine the appropriate course of action; declare weapons nonoperational that could have been affected by the fault; keep weapons in nonoperational status and do not load them on a combat delivery aircraft until authorized by AFNWC/NC; and prohibit performance of electrical checks on these weapons unless directed by AFNWC/NC or until the original fault is resolved and the weapons have been returned to operational status.

7.1.1.2. Nuclear weapons must remain isolated until the fault is identified, located, and corrected or the fault is isolated to a launcher assembly/nuclear weapon. Only then can the aircraft be operationally certified (that is, tested to verify system operability and safety) as being mission capable. When personnel can't identify the cause of the fault, they must get the operating MAJCOM to authorize the aircraft operational certification. However, upon receipt of proper command authority, the aircraft may be declared operationally certified if each of these conditions are met: **(T-1)**.

7.1.1.2.1. A substitute aircraft is not available.

7.1.1.2.2. Nuclear weapon system safety rules and TO restrictions are not violated.

7.1.1.2.3. The fault is isolated to either specific weapon stations or a component associated only with those stations and the faulty stations are not loaded.

7.1.1.2.4. The fault cannot cause or contribute to a critical fault on any loaded station. ***Note:*** *As used here, "station" refers to an individual weapon location rather than a carriage store or launcher connection.*

7.1.1.2.5. Competent authority (not lower than the maintenance group commander or equivalent) approves the loading.

7.1.1.3. Identify faults unmistakably before declaring them noncritical. If the BIT system's fault identification is ambiguous or inconclusive or if personnel cannot

confidently assess the potential hazards associated with corrective actions, treat the fault as critical.

7.1.1.4. Treat as critical any nuclear system fault that prevents electrical monitoring of the nuclear weapon's status. This condition includes hardware and software failures that prevent execution of the monitoring function and failures that prevent proper display of the results of a monitoring function. Treat all other faults as Noncritical.

7.1.2. **Noncritical Faults.** For faults that the engineering MAJCOM has determined to be noncritical, the nuclear weapons may remain electrically mated during troubleshooting operations. However, every attempt should be made to isolate the weapons unless isolating the weapons causes a severe operational impact. **(T-1)**.

7.1.2.1. Before developing troubleshooting procedures, the engineering MAJCOM will delineate specific instructions for each BIT system fault that verify the reliability and accuracy of BIT data, assess the potential consequences of the actions for each fault to assure troubleshooting will not adversely impact nuclear safety, and request evaluation and approval from AFSEC/SEW before troubleshooting noncritical faults.

7.2. **Mechanical Mating Problems.** When a mechanical mating problem occurs that prevents load completion, visually verify no obvious damage exists to electrical connections with the aircraft nuclear system before proceeding with the loading operation. **(T-1)**.

7.2.1. If resolving the mechanical problem doesn't involve the aircraft nuclear system (for example, an out-of-adjustment bomb rack rigging or a physically incompatible pullout cable), proceed with the loading operation after correcting the mechanical problem. The aircraft remains operationally certified. **(T-1)**.

7.2.2. If resolving the mechanical problem requires removing and replacing or reinstalling a component in the aircraft nuclear system, operationally certify the aircraft after correcting the mechanical problem. **(T-1)**.

7.2.3. If mechanical mating problems lead to potential aircraft or weapon damage, complete applicable technical order inspection procedures prior to subsequent mating. **(T-1)**.

7.3. **Electrical Power Application.** Keep application of electrical power to a loaded nuclear combat aircraft to a minimum. **(T-1)**.

7.4. **Minor Maintenance.** Perform only minor maintenance and operational checks not related to the nuclear weapon interface according to approved technical data and the nuclear weapon system safety rules. Examples of these operations include preflight checks, aircraft servicing, aircraft towing, fuel management actions, operational checks of lighting, navigation, radar, and communications systems, and load software into aircraft control processors prior to application of monitor power. **(T-1)**.

7.5. **Nonnuclear System Faults.** When a fault occurs outside the nuclear system on a loaded nuclear combat aircraft, perform corrective actions according to specific aircraft TOs. When corrective actions for a nonnuclear fault require personnel to de-mate weapons,

perform all postload electrical and mechanical checks after mating the weapons. The aircraft remains operationally certified. **(T-1)**.

7.6. **Prohibited Maintenance.** Observe the restrictions described in TO 11A-1-33, *Handling and Maintenance of Explosives Loaded Aircraft.* In addition, personnel must not conduct these specific maintenance actions on loaded nuclear combat aircraft as well as noncombat delivery vehicles (cargo aircraft) with nuclear weapons aboard: **(T-1)**.

7.6.1. Aircraft engine and Alternate Power Unit changes.

7.6.2. Landing gear maintenance requiring fuselage jacking.

7.6.3. Major structural repair.

7.6.4. Disruptions to fuel system, with the exception of fuel management ops (i.e. "topping-off") associated with keeping an aircraft mission ready.

7.6.5. Repairing the launcher primary structure or any other structure that directly supports the loaded nuclear weapon or nuclear weapon system.

8. Criteria Unique to Ground-Launched Missile Systems. Use only approved procedures to perform troubleshooting and maintenance operations while a warhead or reentry system is mated to the missile. If maintenance personnel cannot identify the fault by using approved procedures, remove the warhead or reentry system before proceeding. **(T-0)**.

8.1. Prohibit procedures that could send signals to a warhead or reentry system, jeopardize the safety of the warhead, reentry system, launch system, or launch control system, or arm or bypass safety interlocks. **(T-0)**.

8.2. Only use equipment listed in the MNCL and published technical orders to troubleshoot any fault or failure in the missile, its associated equipment, or any component that is part of the command and control of the missile. ***Note:*** *Troubleshooting does not include replacing the "most likely to fail" item when personnel replace the item using approved technical data.* **(T-1)**.

8.3. When faults occur that personnel cannot identify by using approved procedures, the operating MAJCOM must provide guidance after consulting with the engineering MAJCOM, AFNWC/NC, and AFSEC/SEW.

8.4. Do not conduct these maintenance operations on a loaded nuclear missile system **(T-1)**:

8.4.1. Welding operations in or on the launcher (unless specifically authorized by the engineering MAJCOM).

8.4.2. System-level testing that could inject critical commands.

8.4.3. Use of uncertified test equipment.

8.4.4. Suspension system work (except minor servicing or repair).

8.4.5. Ordnance testing or activation.

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Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

AFI 63-103, *Joint Air Force-National Nuclear Security Administration (AF-NNSA) Nuclear Weapons Life Cycle Management,* 24 September 2008

AFI 63-125, *Nuclear Certification Program*, 8 August 2012

AFI 91-101, *Air Force Nuclear Weapons Surety Program,* 13 October 2010

AFI 91-103, *Air Force Nuclear Safety Design Certification Program*, 17 November 2010

AFMAN 33-363, *Management of Records,* 1 March 2008

AFMAN 91-118, *Safety Design and Evaluation Criteria for Nuclear Weapon Systems,* 4 August 2010

AFMAN 91-119, *Safety Design and Evaluation Criteria for Nuclear Weapons Systems Software,* 5 June 2012

AFPD 13-5, *Air Force Nuclear Enterprise,* 6 July 2011

AFPD 91-1, *Nuclear Weapons and Systems Surety,* 13 December 2010

DODD 3150.2M *Nuclear Weapons System Safety Program Manual*, 23 December 1996

TO 11A-1-33, *Handling and Maintenance of Explosives Loaded Aircraft,* 27 May 2009

Adopted Forms

AF Form 847, *Recommendation for Change of Publication*

Abbreviations and Acronyms

AFNWC—Air Force Nuclear Weapons Center

AFNWC/NC—Air Force Nuclear Weapons Center, Nuclear Capabilities Directorate

AFR—Air Force Reserve

AFSEC/SEW—Air Force Safety Center, Weapons Safety Division

AFSEC/SEWN—Air Force Safety Center, Weapons Safety Division, Nuclear Weapons Safety Branch

ANG—Air National Guard

A&F—Arming and Fuzing

BIT—Built-In Test

DoD—Department of Defense

USAF/SE—US Air Force, Chief of Safety

MAJCOM—Major Command

MNCL—Master Nuclear Certification Listing

OPR—Office of Primary Responsibilities

RDS—Air Force Records Disposition Schedule

TO—Technical Order